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(54) **DISCRETE INPUT DETERMINING CIRCUIT AND METHOD**

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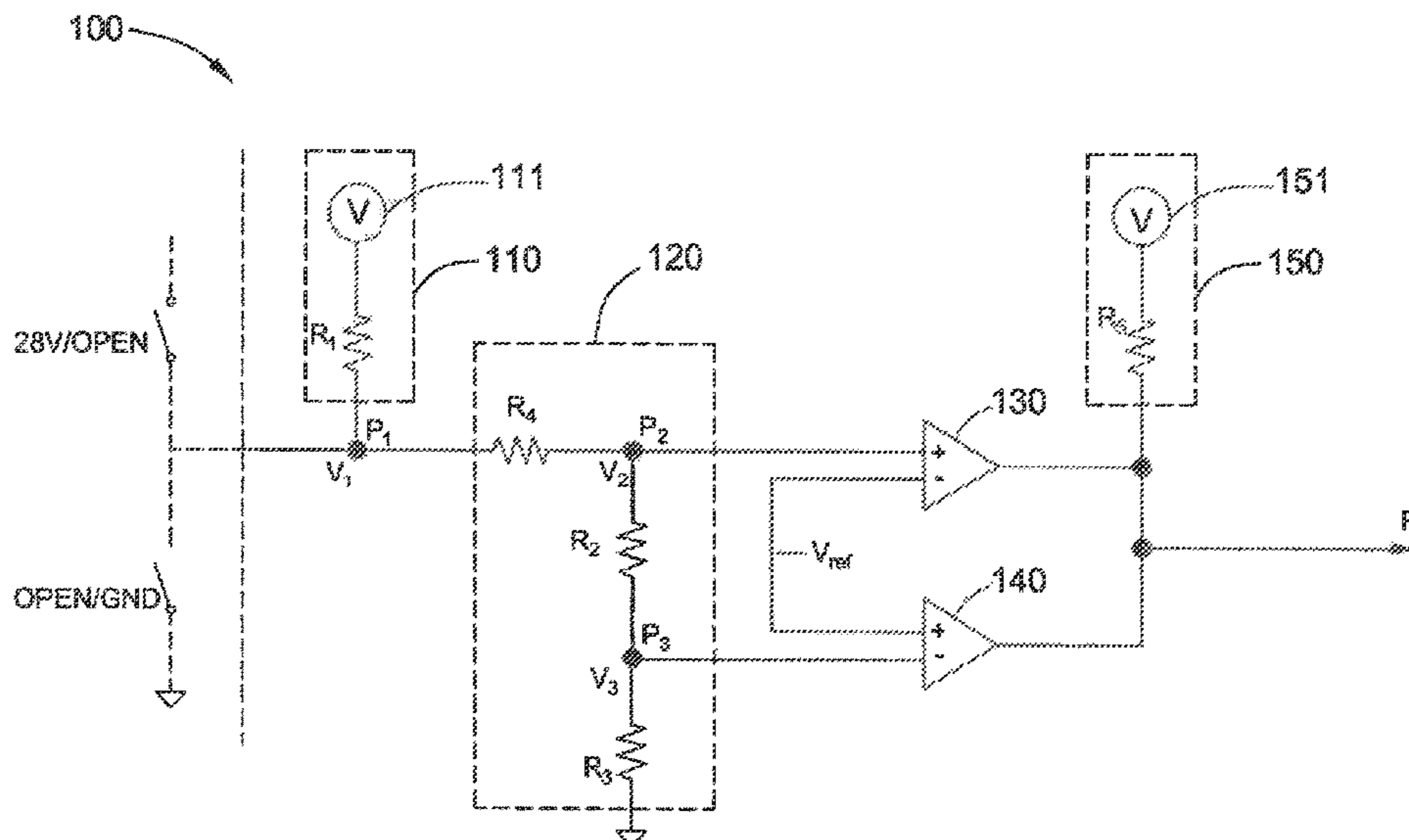
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(57) **ABSTRACT**

A discrete input determining circuit is disclosed, which includes an input biasing network connected to a discrete input for providing a first input voltage, a voltage divider network for dividing the first input voltage into a second input voltage and a third input voltage, a first comparator, wherein a non-inverting input terminal of the first comparator receives the second input voltage, and a second comparator, wherein an inverting input terminal of the second comparator receives the third input voltage, wherein an inverting input terminal of the first comparator and a non-inverting input terminal of the second comparator receive a reference voltage, and an output terminal of the first comparator and an output terminal of the second comparator are configured to provide a logic output. A discrete input determining method is also disclosed.

13 Claims, 2 Drawing Sheets



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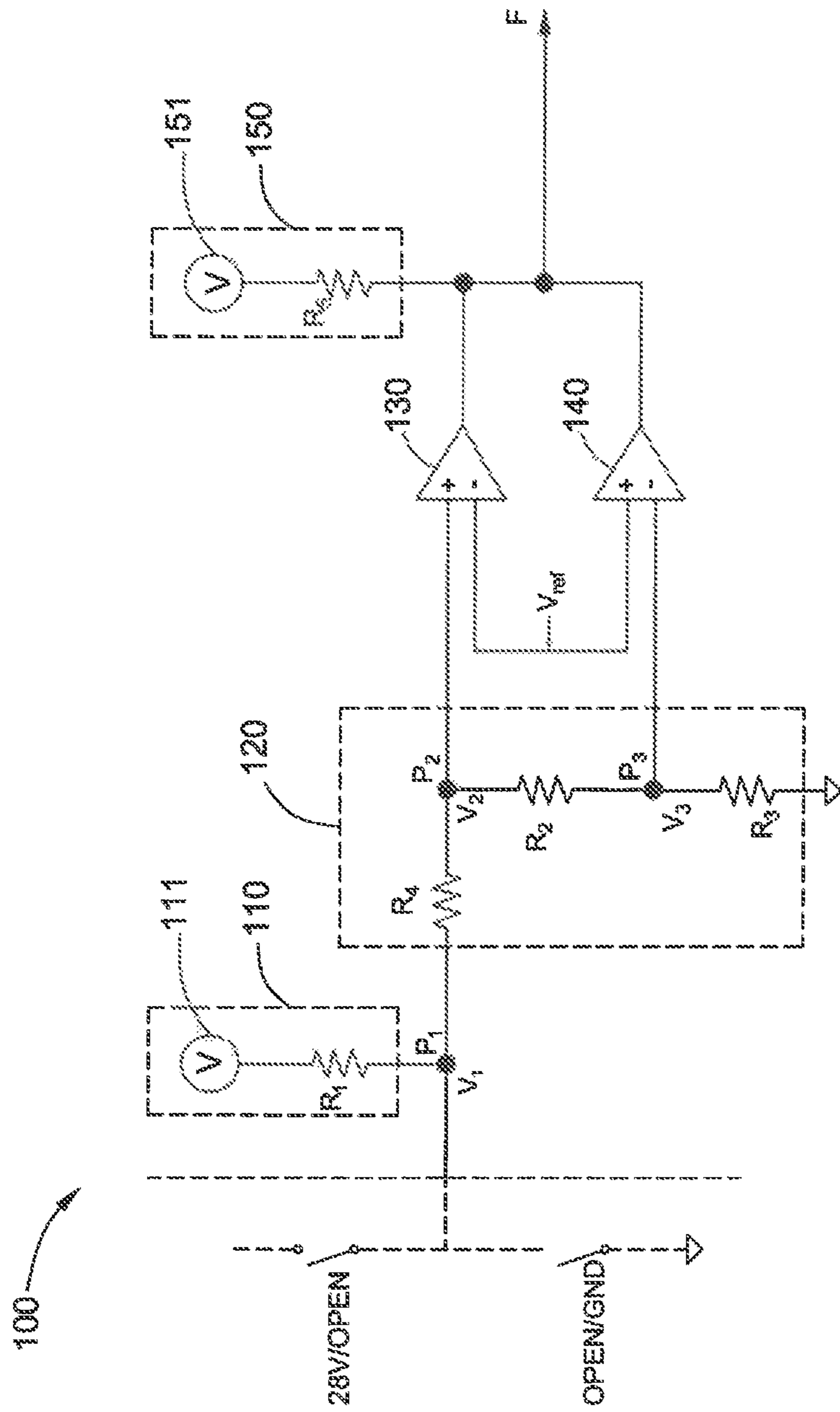


FIG. 1

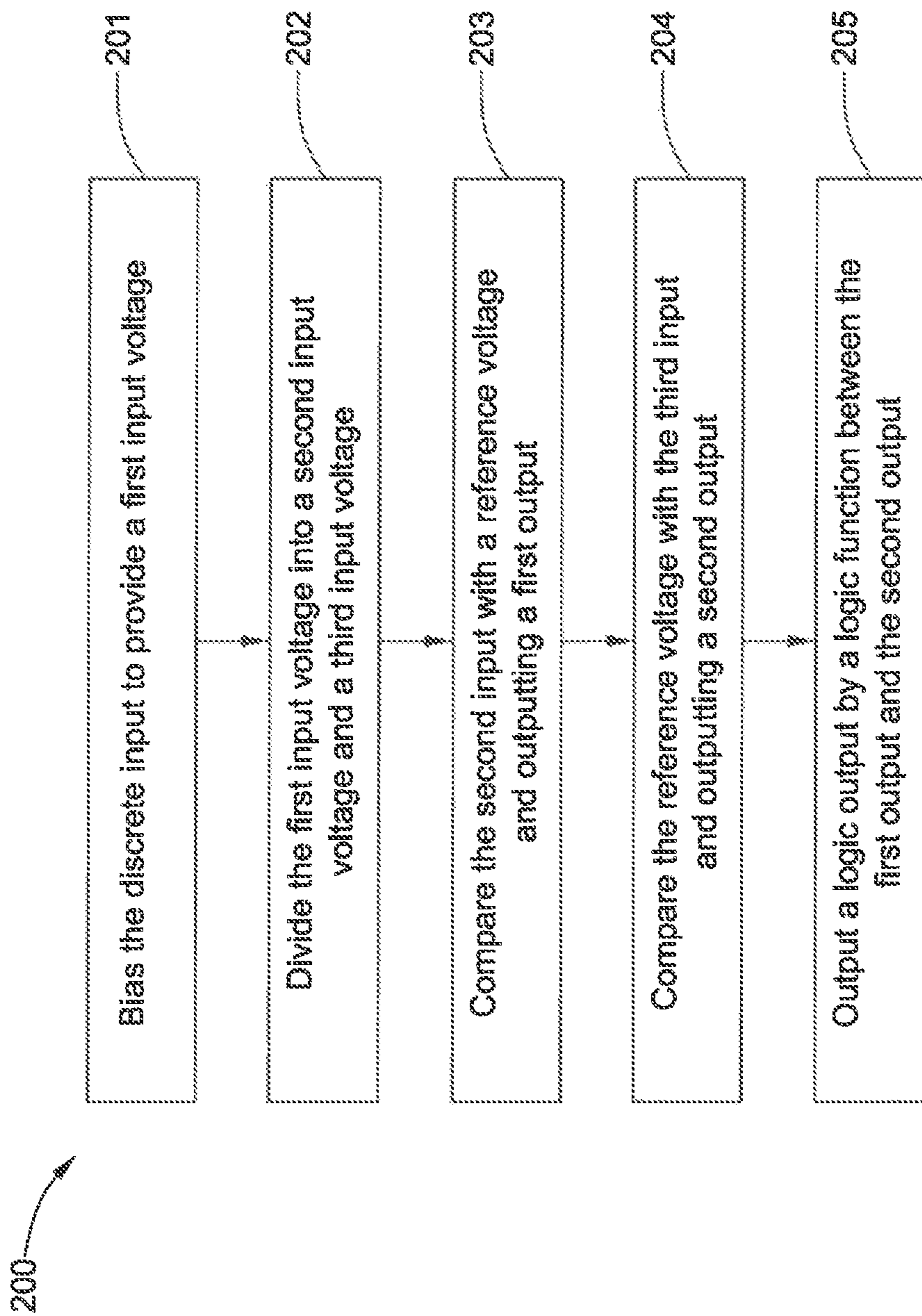


FIG. 2

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DISCRETE INPUT DETERMINING CIRCUIT AND METHOD

CROSS REFERENCE TO RELATED APPLICATION(S)

This application claims priority to and benefit of U.S. patent application Ser. No. 15/726,809 filed Oct. 6, 2017, now allowed, which is incorporated herein in its entirety.

BACKGROUND

This disclosure relates generally to the field of aircraft, and more particularly to a discrete input determining circuit and a discrete input determining method.

Avionics products often provide circuits to read, ascertain or otherwise determine discrete inputs from other equipment in the aircraft. The discrete inputs may conform, for example, to one of two types: OPEN/GND or 28V/OPEN. Avionics products have typically used two different circuits to accommodate the two discrete types, providing internal pullups for the OPEN/GND discrete input and internal pulldowns for 28V/OPEN discrete input. Therefore, the avionics products have frequently provided a quantity of each circuit type to cover a variety of possible aircraft applications. For any given application, rarely are all the discrete inputs of both types utilized, and often there is a shortage of one type or the other. This may result in valuable hardware being left unused, reducing the flexibility and cost-effectiveness of the product.

BRIEF DESCRIPTION

In one aspect, the disclosure relates to a discrete input determining circuit, including an input biasing network connected to a discrete input for providing a first input voltage, a voltage divider network for dividing the first input voltage into a second input voltage and a third input voltage, a first comparator, wherein a non-inverting input terminal of the first comparator receives the second input voltage, and a second comparator, wherein an inverting input terminal of the second comparator receives the third input voltage. An inverting input terminal of the first comparator and a non-inverting input terminal of the second comparator receive a reference voltage, and an output terminal of the first comparator and an output terminal of the second comparator are configured to provide a logic output, and the voltage divider network comprises a second resistive load between the second input voltage and the third input voltage and a third resistive load between the third input voltage and a ground.

In another aspect, the disclosure relates to a method of determining a discrete input, including biasing the discrete input to provide a first input voltage, dividing the first input voltage into a second input voltage and a third input voltage by way of a disposing a second resistive load between the second input voltage and the third input voltage and a third resistive load between the third input voltage and a ground, comparing the second input voltage with a reference voltage and outputting a first output, comparing the reference voltage with the third input voltage and outputting a second output, and outputting a logic output by a logic function between the first output and the second output.

In yet another aspect, the disclosure relates to a method of determining a discrete input, including biasing the discrete input to provide a first input voltage, dividing the first input voltage into a second input voltage and a third input voltage, comparing the second input voltage with a reference voltage

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and outputting a first output, comparing the reference voltage with the third input voltage and outputting a second output, and outputting a logic output by a logic function between the first output and the second output. The first input voltage is less than a positive voltage of the discrete input, and the second input voltage is less than the first input voltage, and the third input voltage is less than the second input voltage

DRAWINGS

These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. 1 is an example schematic diagram of a discrete input determining circuit in accordance with aspects described herein; and

FIG. 2 is an example flow chart of a discrete input determining method in accordance with aspects described herein.

DETAILED DESCRIPTION

Embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the disclosure in unnecessary detail.

Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this disclosure belongs. The terms “first”, “second”, and the like, as used herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. Also, the terms “a” and “an” do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items. The term “or” is meant to be inclusive and mean either or all of the listed items. The use of “including,” “comprising” or “having” and variations thereof herein are meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms “connected” and “coupled” are not restricted to physical or mechanical connections or couplings, and can include electrical connections or couplings, whether direct or indirect. In addition, Terms indicating specific locations, such as “top”, “bottom”, “left”, and “right”, are descriptions with reference to specific accompanying drawings. Embodiments disclosed in the present disclosure may be placed in a manner different from that shown in the figures. Therefore, the location terms used herein should not be limited to locations described in specific embodiments.

FIG. 1 illustrates a schematic diagram of a discrete input determining circuit 100. As shown in FIG. 1, the discrete input determining circuit 100 comprises an input biasing network 110 connected to a discrete input for providing a first input voltage V_1 , a voltage divider network 120 for dividing the first input voltage V_1 into a second input voltage V_2 and a third input voltage V_3 , a first comparator 130 and a second comparator 140. A non-inverting input terminal “+” of the first comparator 130 receives the second input voltage V_2 , and an inverting input terminal “-” of the second comparator 140 receives the third input voltage V_3 . An inverting input terminal “-” of the first comparator 130 and a non-inverting input terminal “+” of the second comparator

140 receive a reference voltage V_{ref} . An output terminal of the first comparator **130** and an output terminal of the second comparator **140** are configured to provide a logic output F.

In one embodiment, the input biasing network **110** comprises a first power supply **111** and a first resistive load R_1 . The first resistive load R_1 is connected between the discrete input and the first power supply **111**, and a node P_1 between the discrete input and the first resistive load R_1 is connected to the voltage divider network **120**. When the discrete input is in the OPEN state, the first input voltage V_1 is a voltage at the node P_1 and the first input voltage V_1 is less than a positive voltage $V+$ of the discrete input, for example, the positive voltage $V+$ is equal to 28 volts. It is to be appreciated that 28 volts is used herein for illustrative purposes; however, virtually any voltage would be within the scope of the subject innovation.

The voltage divider network **120** can include a second resistive load R_2 and a third resistive load R_3 connection in series between the node P_1 and a ground. The second input voltage V_2 is a voltage at a node P_2 between the node P_1 and the second resistive load R_2 , and the third input voltage V_3 is a voltage at a node P_3 between the second resistive load R_2 and the third resistive load R_3 . In this case, the second input voltage V_2 is less than the first input voltage V_1 , and the third input voltage V_3 is less than the second input voltage V_2 . In another embodiment, the voltage divider network **120** further comprises a fourth resistive load R_4 connection in series between the node P_1 and the node P_2 , in this case, the second input voltage V_2 is less than the first input voltage V_1 . In one embodiment, when the discrete input is in an OPEN state, the first input voltage V_1 is determined by the relationship among the first power supply **111**, the first resistive load R_1 , the second resistive load R_2 , the third resistive load R_3 , and the fourth resistive load R_4 .

As for the first comparator **130**, the non-inverting input terminal “+” can be connected to the node P_2 for receiving the second input voltage V_2 , and the inverting input terminal “-” receives the reference voltage V_{ref} . For example, when the second input voltage V_2 is larger than the reference voltage V_{ref} the first comparator **130** outputs a logic high level; when the second input voltage V_2 is less than the reference voltage V_{ref} the first comparator **130** outputs a logic low level. As for the second comparator **140**, the non-inverting input terminal “+” receives the reference voltage V_{ref} and the inverting input terminal “-” is connected to the node P_3 for receiving the third input voltage V_3 . When the third input voltage V_3 is larger than the reference voltage V_{ref} the second comparator **140** outputs the logic low level; when the third input voltage V_3 is less than the reference voltage V_{ref} the second comparator **140** outputs the logic high level. In an optional embodiment, the first comparator **130** and the second comparator **140** can be replaced by a window comparator or a dual comparator.

The output terminal of the first comparator **130** and the output terminal of the second comparator **140** can be open-collector type outputs that are wired together to implement a logic AND function so as to provide the logic output F, in this case, the discrete input determining circuit **100** further comprises an output configuration network **150**, wherein the output configuration network **150** comprises a second power supply **151** and a fifth resistive load R_5 connected between the second power supply **151** and the logic output F.

The discrete input determining circuit **100** can accommodate both OPEN/GND and 28V/OPEN discrete input types, and application of the discrete input determining circuit is more flexible and cost effective. The logic output can be routed to any general-purpose input or output (GPIO) pin on

a microprocessor or a field programmable gate array (FPGA) used for the host product data processing.

FIG. 2 illustrates a flow chart of a discrete input determining method **200** in accordance with an embodiment of the present disclosure. The discrete input determining method **200** may include the steps as follows.

In step **201**, a first input voltage is provided by biasing a discrete input.

In step **202**, the first input voltage is divided into a second input voltage and a third input voltage. In one embodiment, the first input voltage is less than the positive voltage of the discrete input, and the second input voltage is less than the first input voltage, and the third input voltage is less than the second input voltage.

In step **203**, the second input voltage is compared with a reference voltage and a first output signal is outputted. In one embodiment, when the discrete input is in an OPEN state, the second input voltage is larger than the reference voltage so that the first output is a logic high level; when the discrete input is in the positive voltage state, the second input voltage is larger than the reference voltage so that the first output is the logic high level; when the discrete input is in a GND state, the second input voltage is less than the reference voltage so that the first output voltage is a logic low level.

In step **204**, the reference voltage is compared with the third input voltage and a second output is outputted. In one embodiment, when the discrete input is in the OPEN state, the reference voltage is larger than the third input voltage so that the second output is the logic high level; when the discrete input is in the positive voltage state, the reference voltage is less than the third input voltage so that the second output is the logic low level; when the discrete input is in the GND state, the reference voltage is larger than the third input voltage so that the second output is the logic high level.

In step **205**, a logic output is outputted by a logic function between the first output and the second output. In one embodiment, the logic function comprises a logic AND function, wherein when the discrete input is in the OPEN state, the logic output is the logic high level; when the discrete input is in the positive voltage state or the GND state, the logic output is the logic low level.

While steps of the discrete input determining method in accordance with embodiments of the present disclosure are illustrated as functional blocks, the order of the blocks and the separation of the steps among the various blocks shown in FIG. 2 are not intended to be limiting. For example, the blocks may be performed in a different order and a step associated with one block may be combined with one or more other blocks or may be sub-divided into a number of blocks.

While the disclosure has been illustrated and described in typical embodiments, it is not intended to be limited to the details shown, since various modifications and substitutions can be made without departing in any way from the spirit of the present disclosure. As such, further modifications and equivalents of the disclosure herein disclosed may occur to persons skilled in the art using no more than routine experimentation, and all such modifications and equivalents are believed to be within the spirit and scope of the disclosure as defined by the following claims.

The invention claimed is:

1. A discrete input determining circuit, comprising: an input biasing network connected to a discrete input for providing a first input voltage;

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a voltage divider network for dividing the first input voltage into a second input voltage and a third input voltage;
 a first comparator, wherein a non-inverting input terminal of the first comparator receives the second input voltage; and
 a second comparator, wherein an inverting input terminal of the second comparator receives the third input voltage;
 wherein an inverting input terminal of the first comparator and a non-inverting input terminal of the second comparator receive a reference voltage, and an output terminal of the first comparator and an output terminal of the second comparator are configured to provide a logic output; and
 wherein the voltage divider network comprises a second resistive load between the second input voltage and the third input voltage and a third resistive load between the third input voltage and a ground.

2. The discrete input determining circuit according to claim 1, wherein the input biasing network comprises a first power supply and a first resistive load connected between the discrete input and the first power supply, and a node between the discrete input and the first resistive load is connected to the voltage divider network.

3. The discrete input determining circuit according to claim 1, wherein the first input voltage is less than a positive voltage of the discrete input.

4. The discrete input determining circuit according to claim 1, wherein the voltage divider network further comprises a fourth resistive load between the first input voltage and the second input voltage.

5. The discrete input determining circuit according to claim 1, wherein the output terminal of the first comparator and the output terminal of the second comparator are wired together to implement a logic AND function so as to provide the logic output.

6. The discrete input determining circuit according to claim 5, further comprising an output configuration network comprising a second power supply and a fifth resistive load connected between the second power supply and the logic output.

7. A method of determining a discrete input, comprising:
 biasing the discrete input to provide a first input voltage;
 dividing the first input voltage into a second input voltage and a third input voltage by way of a disposing a second resistive load between the second input voltage and the third input voltage and a third resistive load between the third input voltage and a ground;
 comparing the second input voltage with a reference voltage and outputting a first output;
 comparing the reference voltage with the third input voltage and outputting a second output; and
 outputting a logic output by a logic function between the first output and the second output.

8. The method according to claim 7, wherein when the discrete input is in an OPEN state, the second input voltage is larger than the reference voltage so that the first output is a logic high level, and the reference voltage is larger than the third input voltage so that the second output is the logic high level.

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9. The method according to claim 7, wherein when the discrete input is in a positive voltage state, the second input voltage is larger than the reference voltage so that the first output is a logic high level, and the reference voltage is less than the third input voltage so that the second output is a logic low level.

10. The method according to claim 7, wherein when the discrete input is in a GND state, the second input voltage is less than the reference voltage so that the first output is a logic low level, and the reference voltage is larger than the third input voltage so that the second output is a logic high level.

11. The method according to claim 7, wherein the logic function comprises a logic AND function, wherein the logic output is a logic high level when the discrete input is in an OPEN state, the logic output is a logic low level when the discrete input is in a GND state, and the logic output is a logic low level when the discrete input is in a positive voltage state.

12. A method of determining a discrete input, comprising:
 biasing the discrete input to provide a first input voltage;
 dividing the first input voltage into a second input voltage and a third input voltage;
 comparing the second input voltage with a reference voltage and outputting a first output;
 comparing the reference voltage with the third input voltage and outputting a second output; and
 outputting a logic output by a logic function between the first output and the second output;
 wherein the first input voltage is less than a positive voltage of the discrete input, and the second input voltage is less than the first input voltage, and the third input voltage is less than the second input voltage;
 wherein the discrete input is any one of an OPEN state, positive voltage, and GND state;
 wherein when the discrete input is in an OPEN state, the second input voltage is larger than the reference voltage so that the first output is a logic high level, and the reference voltage is larger than the third input voltage so that the second output is the logic high level;
 wherein when the discrete input is in a positive voltage state, the second input voltage is larger than the reference voltage so that the first output is a logic high level, and the reference voltage is less than the third input voltage so that the second output is a logic low level;
 wherein when the discrete input is in a GND state, the second input voltage is less than the reference voltage so that the first output is a logic low level, and the reference voltage is larger than the third input voltage so that the second output is a logic high level.

13. The method according to claim 12, wherein the logic function comprises a logic AND function, wherein the logic output is a logic high level when the discrete input is in an OPEN state, the logic output is a logic low level when the discrete input is in a GND state, and the logic output is a logic low level when the discrete input is in a positive voltage state.

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